Differences in water hardness and longevity rates in the Peninsula of Nicoya in Guanacaste and the other districts, Costa Rica

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Keywords

Water hardness; longevity rate; Blue Zone.

Abstract

Objective: To analyze drinking-water hardness characteristics and the longevity rates/10.000 inhabitants of the districts within the Nicoya Peninsula (‘Blue Zone') and the rest of Guanacaste Province in Costa Rica. The aim is to determine whether mineral content of water is a protective factor for quality long life.

Methodology: six steps were followed in order to meet the objective of this present study. First step was to perform at least 3.000 physical-chemical analysis of drinking-water, from 425 aqueducts of the 59 districts of Guanacaste. Secondly total hardness (calcium carbonate + magnesium carbonate) was calculated using average values for each district. Third, using data from 2011 Census longevity average rates/10.000 inhabitants were determined for three different age ranges: 80-89, 90-99, and >100 years old. Fourth step was to perform a frequency analysis, placing the longevity average rates throughout the total hardness ranges: 0-90, >90-180, >180- 270, and >270 mg/L. These data was used to analyze trends between total water hardness and longevity rates for each district. Fifth step consisted in the identification of the 29 districts of the ‘Blue Zone', located within the Nicoya Peninsula. The total hardness values were compared to the longevity average rates/10.000 inhabitants values from the other 30 districts, used as control. Sixth step was to implement the ‘Student's t-test' for the differences between longevity within the three age ranges, in order to verify whether there was a statistically significant difference with 90% (p=<0,10), 95% (p=<0,05), and 99% (p=<0,01) confidence.

Results

Total drinking-water hardness averages show that 21 districts (35,6%) use ‘soft' water, 23 (39%) ‘moderately hard' water, 11 (18,6%) ‘hard' water, and 4 (5,8%) ‘very hard' water. Trend analysis between the four total hardness ranges and the longevity average rates, within the age rates of 80-89 and 90-99 years old, indicate there is a positive correlation between both factors along the 59 districts: the harder the water is the higher longevity rate. On the other hand, water hardness averages appear to be markedly higher for the ‘Blue Zone' than for the control districts throughout the three age ranges. However, the differences are statistically significant with 95% confidence in the first group (80-89 years old) and 90% in the second one (90-99 years old).

Conclusions

The results show there is a positive correlation between the consumption of ‘hard' water and the longevity rates within people >80 years old. Drinking mineralized water for long periods of time is a protective factor for longevity and quality of life.

Recommendations

To verify if consumption of ‘hard' water is a common protective factor for longevity within the remaining ‘Blue Zone' throughout the world, i.e. Sardinia (Italy), Okinawa (Japan), Loma Linda (California, USA), and Icaria (Greece).

Introduction

Water hardness (DA) or limestone — as opposed to “soft” water — is one that contains a high level of minerals, particularly calcium and magnesium salts (Miñara, 2002). It is normally expressed as the amount of calcium carbonate, and is calculated generically from the sum of the concentrations of calcium carbonate and magnesium carbonate, in mg / L, existing in each liter of water. According to the World Health Organization (WHO), the degree of AD is classified based on CaCO3, in 4 intervals of 0-60 mg / L, and is defined as “soft”, between 61-120 mg / L as “Moderately hard”, 121-180 mg / L is classified as “hard” and> 180 mg / L as “very hard” (WHO, 2004). However, and for the present study, given that the calcium / magnesium ratio is generally about the double, in Costa Rica the alternative of adding both minerals to calculate the DA was adopted, so the intervals of 0 were defined -90 mg / L as “soft”,> 90-180 mg / L as “moderately hard”,> 180-270 mg / L as “hard” and> 270 mg / L as “very hard” (Mora, Portuguez, Alfaro, 2001).

DA can be temporary (carbonates) or permanent (noncarbonates), usually sulfates and chlorides. The hardness of calcium carbonate and magnesium carbonate are less soluble in hot water than in cold water; that is, when the water is boiled, the DA can decrease when it precipitates; on the contrary, the permanent hardness of sulfate salts and calcium or magnesium chlorides does not decrease when the water is boiled.

Another important and visible difference is that “hard” waters are encrusting, forming tartar or deposits of calcium carbonate in the pipes, boilers and other types of containers that contain it. The “Soft” waters are corrosive and demineralized, inducing the leaching of the container material that contains them, such as storage tanks and the distribution network of water supply systems for human consumption (ACH) (Mora, 2009). With regard to the relationship between the degree of AD and the health of consumers, the first observation made Hippocrates wise approximately 2,500 years ago in its ecological document entitled “Airs, waters and places”

In this document Hippocrates indicated to his medical students that “…*Whoever wishes to study medicine correctly should proceed among other aspects, as follows ... They should consider with greater care all these things and, also where the natives have to go to look for water, if they use swampy, soft waters or hard waters that come from high and rocky places, if the soil is healthy and rough or if it is flat and dry, if wooded and with abundant waters ...”*(WHO, 1948); that is, according to Hippocrates, the health of the population will depend, among other factors, on the physical-chemical characteristics of water, especially its "hardness" or "softness".

In the twentieth century, some studies have shown a weak inverse relationship between AD and cardiovascular disease in men, when the degree of total water hardness exceeds 170 170 mg / L calcium carbonate (WHO, 1994) (Calvo, Sardiñas, 1992). However, WHO (World Health Organization) has reviewed the evidence, and concluded that the data were inadequate to issue a recommendation about a level of AD (WHO, 2004). Other studies, carried out both at the level of Costa Rica and in other latitudes of the world, indicate that excess DA has been linked as a risk factor for renal lithiasis (Mora, Chamizo, 2007) (Medina-Escobeto, 2002). In the global context, and related to the longevity of people, several places or populations called “Blue Zones” have been identified, where people live longer and, in many cases, exceeds 100 years of age (Buettner, 2002) (Buettner, 2008). These regions were studied by Dan Buettner of the National Geographic, pointing out specific local characteristics and cultural practices that

generate high incidence of longevity cases. The 5 “Blue Zones” identified so far are:

• Sardinia, **Italy** (specifically in the province of Nuoro and Ogliastra).

• Okinawa Island, **Japan**.

• Loma Linda, California, **USA**

• Icaria, Island of **Greece** near the Turkish coast.

• The Nicoya Península, **Costa Rica**.

According to several researchers, the main factors that favor the longevity of the population of these “Blue Zones” are nutrition focused on the intake of minerals, through the consumption of vegetables and “hard” waters with high calcium and magnesium contents (Grainger, 2009) (Winfrey, 2009). Other important aspects are the philosophy of life of citizens with little "stress", natural exercise in their work and the genetics of the inhabitants (Buettner, 2011). Specifically, in the Nicoya Peninsula most of these aspects are fulfilled, especially the consumption of mineralized water and corn tortillas "cured" with calcium carbonate. These factors together cause greater longevity, strength, vitality and happiness in the inhabitants of the "Blue Zone" of the Nicoya Peninsula (National Water Laboratory, 2014)

Currently, calcium is known to be responsible for structural functions that affect the skeleton and soft tissues, and regulatory functions such as the neuromuscular transmission of chemical and electrical stimuli, including heart movement, cell secretion and blood clotting. More than 99% of the body's calcium is found in the bones. This divalent cation is the most abundant in the human organism, and constitutes between 1.5% and 2.0% of the total body weight (WHO / PAHO, 1997).

Magnesium plays an essential role in many basic brain reactions, so that its deficiency can lead to various electrochemical disorders. A human body weighting 155 pounds has about 20 to 28 g of magnesium. In myocardial infarction, intravenous administration of magnesium reduces the frequency of severe arrhythmias and mortality. As noted, this is an essential mineral that is acquired through diet, mainly from vegetables and ACH. For example, in Costa Rica, according to studies carried out at the National Water Laboratory, this liquid contributes an average of 4.6% to the daily diet of Costa Rica (Mora, 2000).

Because of this, and the role that calcium and magnesium play in human physiology (Ten, Yusuf, Collin, 1991) (Suárez, 2012), the present study is carried out, with the aim of analyzing the characteristics of DA and the district longevity rates of the inhabitants in the “Blue Zone” of the Nicoya peninsula and the rest of the districts of the province of Guanacaste, with the purpose of determining whether or not the mineral content of the water is a protective factor of quality and long life of the Chorotega region.

Materials and methods

To fulfill the objective of this ecological-descriptive-retrospective-analytical study, the following steps were applied:

Average total hardness, calcium hardness and magnesium hardness in water by district

The ACH total hardness averages, in each of the 59 districts of Guanacaste, were calculated with at least 3000 physicochemical analyzes, coming from the waters of 425

aqueducts of the 11 cantons of the Chorotega region, in the period from 2007 to 2013. These data were obtained from the historical data of the National Water Laboratory.

Classification of total water hardness

As indicated in the introduction, the classification of DA was performed using the following 4 intervals:
"Soft" water of 0–90 mg / L.
"Moderately hard" water of> 90–180 mg / L. "Hard" water of> 180–270 mg / L.
"Very hard" water> 270 mg / L.

Data on longevity rates by districts

Based on the results of the 2011 Census (INEC, 2012), the number of people was determined by districts of Guanacaste between the ages of 80-89, 90-99 and +100 years. With these data, longevity rates / 10,000 inhabitants were calculated for each population segment, then locate these average longevity results in the four total hardness intervals.

Trend analysis in the 59 districts

With the intervals of total hardness and the average longevity rates / 10,000 inhabitants, a frequency analysis was prepared, with the purpose of identifying the trend by means of a table and its respective graph, thus assessing the hypothesis that "The higher the DA, the higher the longevity rates / 10,000 inhabitants, distributed in the segments of 80-89, 90-99 and +100 years".

Comparison of total hardness and average longevity rates between the districts of the province of Nicoya and the rest of the districts of Guanacaste

The 29 districts located in the cantons of Nicoya, Hojancha, Santa Cruz, Carrillo and Nandayure (Ávalos, Bran, 2013), have been classified as one of the 5 "Blue Zones" in the world by the number of long-lived people, which can live more than 100 years with quality of life. These were compared with the other 30 districts located in the cantons of Liberia, Cañas, Bagaces, Tilarán, La Cruz and Abangares (not belonging to the "Blue Zone"), with the objective of determining if there are significant statistical differences, in the averages of total hardness and average longevity rates / 10,000 inhabitants, in the 3 age segments.

Statistical analysis

To assess whether the differences between Total Hardness and the respective longevity rates present significant statistical difference, between the intervals of the "Blue Zone" and the control districts in the 3 age segments, the "Student's t-tests" was applied to 90%, 95% and 99% trust (es.wikipedia.org/wiki/Prueba_t de Student, 2014).

These results will allow us to hypothesize that "Total Hardness Concentrations in ACHs are an important factor in maintaining the average longevities by districts in Guanacaste".

Cuadro 1. Average total hardness, calcium hardness and Magnesium hardness and longevity rates / 10,000 inhabitants in the 59 districts of Guanacaste

Districts	Cantons	Hardnes Total mg/L	Hardness Calcium mg/L	Hardness Magnesium mg/L	Relation Mg/Ca	Relation Ca/Mg	Population rates by ages ≥ 80 years		
							80-89	90-99	> 100
Liberia	Liberia	30,00	19,33	10,67	0,55	1,81	113,52	20,61	2,06
Cañas Dulces	Liberia	72,00	46,00	26,00	0,57	1,77	173,37	34,06	0,00
Mayorga	Liberia	262,00	169,00	93,00	0,55	1,82	118,32	37,52	0,00
Nacascolo	Liberia	69,00	39,00	30,00	0,77	1,30	68,93	0,00	0,00
Curubandé	Liberia	77,00	52,50	24,50	0,47	2,14	102,89	31,66	0,00
Nicoya	Nicoya	153,00	95,30	57,70	0,61	1,65	193,69	42,69	3,22
Mansión	Nicoya	250,67	233,34	17,33	0,07	13,46	271,12	43,73	5,25
San Antonio	Nicoya	197,19	147,32	49,87	0,34	2,95	316,17	84,31	1,51
Quebrada Honda	Nicoya	259,56	233,00	26,56	0,11	8,77	352,75	75,81	0,00
Sámara	Nicoya	178,00	127,00	51,00	0,40	2,49	119,59	22,78	2,85
Nosara	Nicoya	167,17	117,83	49,34	0,42	2,39	73,29	22,39	0,00
Belén-Nosarita	Nicoya	107,17	75,28	31,89	0,42	2,36	227,10	40,95	0,00
Santa Cruz	Santa Cruz	200,81	122,23	78,58	0,64	1,56	187,52	45,95	1,39
Bolsón	Santa Cruz	377,50	275,00	102,50	0,37	2,68	319,61	11,39	0,00
Veintisiete de Abril	Santa Cruz	178,67	109,33	69,34	0,63	1,58	209,99	34,05	2,84
Tempate	Santa Cruz	199,08	116,44	82,64	0,71	1,41	119,01	39,08	0,00
Cartagena	Santa Cruz	218,97	135,58	83,39	0,62	1,63	175,21	44,46	5,23
Guajiniquil	Santa Cruz	143,25	80,50	62,75	0,78	1,28	117,38	22,36	0,00
Diriá	Santa Cruz	169,30	62,10	107,20	1,73	0,58	279,13	48,66	0,00
Cabo Velas	Santa Cruz	168,40	92,80	75,60	0,81	1,23	121,95	35,69	0,00
Tamarindo	Santa Cruz	158,00	64,00	94,00	1,47	0,68	105,10	34,51	0,00
Bagaces	Bagaces	41,28	26,14	15,14	0,58	1,73	115,63	29,92	3,23
La Fortuna	Bagaces	120,00	28,75	91,25	3,17	0,32	181,42	29,03	0,00
Mogote	Bagaces	58,13	40,13	18,00	0,45	2,23	114,77	20,60	0,00
Río Naranjo	Bagaces	49,67	30,33	19,34	0,64	1,57	197,04	0,00	0,00
Filadelfia	Carrillo	193,27	130,13	63,14	0,49	2,06	149,63	35,21	2,51
Palmira	Carrillo	193,31	122,14	71,17	0,58	1,72	131,09	44,31	0,00
Sardinal	Carrillo	199,50	119,50	80,00	0,67	1,49	126,74	24,81	2,01
Belén	Carrillo	220,50	126,67	93,83	0,74	1,35	147,04	38,46	1,13
Cañas	Cañas	89,60	50,99	38,61	0,76	1,32	121,54	23,54	1,92
Palmira	Cañas	103,58	51,38	52,20	1,02	0,98	111,34	60,73	0,00
San Miguel	Cañas	105,17	68,50	36,67	0,54	1,87	133,82	42,58	0,00
Bebedero	Cañas	84,50	52,00	32,50	0,63	1,60	86,37	9,60	0,00
Porozal	Cañas	301,00	285,00	16,00	0,06	17,81	179,37	14,95	0,00
Las Juntas	Abangares	87,28	65,56	21,72	0,33	3,02	149,76	34,80	0,00
Sierra	Abangares	50,71	33,88	16,83	0,50	2,01	136,11	17,01	0,00
San Juan	Abangares	83,40	61,20	22,20	0,36	2,76	189,27	12,62	0,00
Colorado	Abangares	287,53	200,61	86,92	0,43	2,31	106,04	34,62	2,16
Tilarán	Tilarán	88,00	48,00	40,00	0,83	1,20	163,65	38,03	3,46
Quebrada Grande	Tilarán	52,01	32,23	19,78	0,61	1,63	170,37	40,74	0,00
Tronadora	Tilarán	35,50	21,49	14,01	0,65	1,53	189,42	11,14	0,00
Santa Rosa	Tilarán	35,00	18,00	17,00	0,94	1,06	195,37	77,12	0,00
Líbano	Tilarán	78,45	55,73	22,72	0,41	2,45	323,70	23,12	0,00
Tierras Morenas	Tilarán	31,10	19,14	11,96	0,62	1,60	213,55	36,82	0,00
Arenal	Tilarán	49,13	34,30	14,83	0,43	2,31	108,70	13,04	0,00
Carmona	Nandayure	175,25	107,50	67,75	0,63	1,59	205,15	64,36	4,02
Santa Rita	Nandayure	173,86	106,57	67,29	0,63	1,58	179,81	82,99	6,92
Zapotal	Nandayure	102,33	55,67	46,66	0,84	1,19	139,92	74,07	0,00
San Pablo	Nandayure	445,50	230,67	214,83	0,93	1,07	167,65	31,72	0,00
Porvenir	Nandayure	115,00	63,00	52,00	0,83	1,21	175,44	53,98	0,00
Bejuco	Nandayure	143,69	93,00	50,69	0,55	1,83	145,41	33,05	3,30
La Cruz	La Cruz	128,97	101,65	27,32	0,27	3,72	109,84	26,10	3,26
Santa Cecilia	La Cruz	36,00	24,00	12,00	0,50	2,00	123,04	30,36	2,85
La Garita	La Cruz	123,25	75,50	47,75	0,63	1,58	118,48	35,55	17,77
Santa Elena	La Cruz	138,50	121,17	17,33	0,14	6,99	107,84	39,22	0,00
Hojancha	Hojancha	145,45	82,84	62,61	0,76	1,32	188,46	47,11	4,71
Monte Romo	Hojancha	55,89	32,11	23,78	0,74	1,35	149,03	14,90	0,00
Puente Carrillo	Hojancha	123,25	73,42	49,83	0,68	1,47	158,83	19,06	6,35
Huacas	Hojancha	130,00	75,13	54,87	0,73	1,37	127,30	56,58	0,00

FUENTE: Laboratorio Nacional de Aguas.

Water analysis

The physical-chemical analyzes of the waters for human consumption were carried out following the guidelines of the "Standard Methods for the Examination of Water and Waste Water" (APHS / AWWA / WEF, 2012).

Results

Table 1 shows the average data of the three types of AD, and the average longevity rates / 10,000 inhabitants in each of the 59 Guanacaste districts.

Total hardness and average longevity rates

Table 2 shows, by intervals, the average total hardness averages and the respective average longevity / 10,000 rates in the 3 segments by age, for each district in Guanacaste.

Total average hardness in the districts of the "Blue Zone" (Nicoya Peninsula), longevity and its comparison with the other control districts of the province of Guanacaste

Table 3 summarizes, in comparative form, the variables of total hardness, calcium hardness and magnesium hardness and longevity / 10,000 inhabitants in the 3 age segments, among the 29 districts of the "Blue Zone" and the 30 control districts.

Table 2. Average total hardness intervals and the respective average longevity rates / 10,000 inhabitants in people> 80 years of age by districts in Guanacaste

Intervals of total hardness (mg/L)	Longevity: Rate per 10 000 population		
	80 to 89yo	90 to 99yo	=+ 100yo
0 - 90	153,62	24,75	0,64
>90 -180	153,49	42,11	2,40
>180 - 270	190,42	46,70	1,73
>270	193,17	23,17	0,54

Source: Author's elaboration

Table 3. The "Blue Zone" and the control districts: total hardness, calcium hardness and magnesium hardness, their proportions and average longevity rates in provinces greater than 80 years

Districts of the "Blue Zone""	Number	Total hardness (mg/L)	$CaCO_3$ (mg/L)	$MgCO_3$ (mg/L)	Ca/Mg	Mg/Ca	Longevity/10.000		
							80-89	90-99	=+ 100yo
	29	184,78	116,85	67,94	2,24	0,66	179,34	42,31	1,77
Districts for control	30	95,44	64,53	30,91	2,57	0,63	146,33	28,45	1,27
Differences		89,34*	52,32*	37,03*	-0,33	0,03	33,01**	13,86*	0,50

Source: Author's elaboration
*Diferencia estadística al 99% de confianza.
** Diferencia estadística al 95% de confianza

In figure 1, the data of table 2 is displayed.

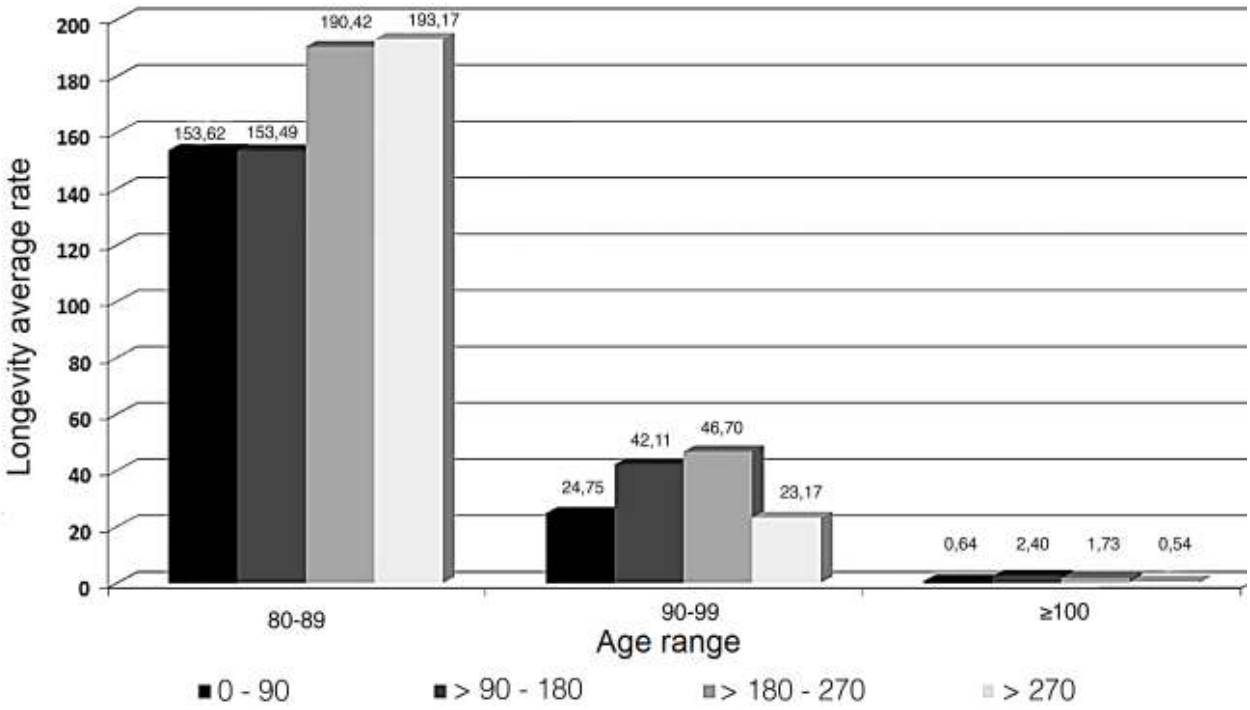

Figura 1. Distritos de Guanacaste: dureza total por intervalos y las tasas promedio de longevidad en personas de 80 a 89, 90 a 99 y Š100 años. Fuente: Elaborado por los autores

In Figure 2, the comparative data of Table 3 is displayed.

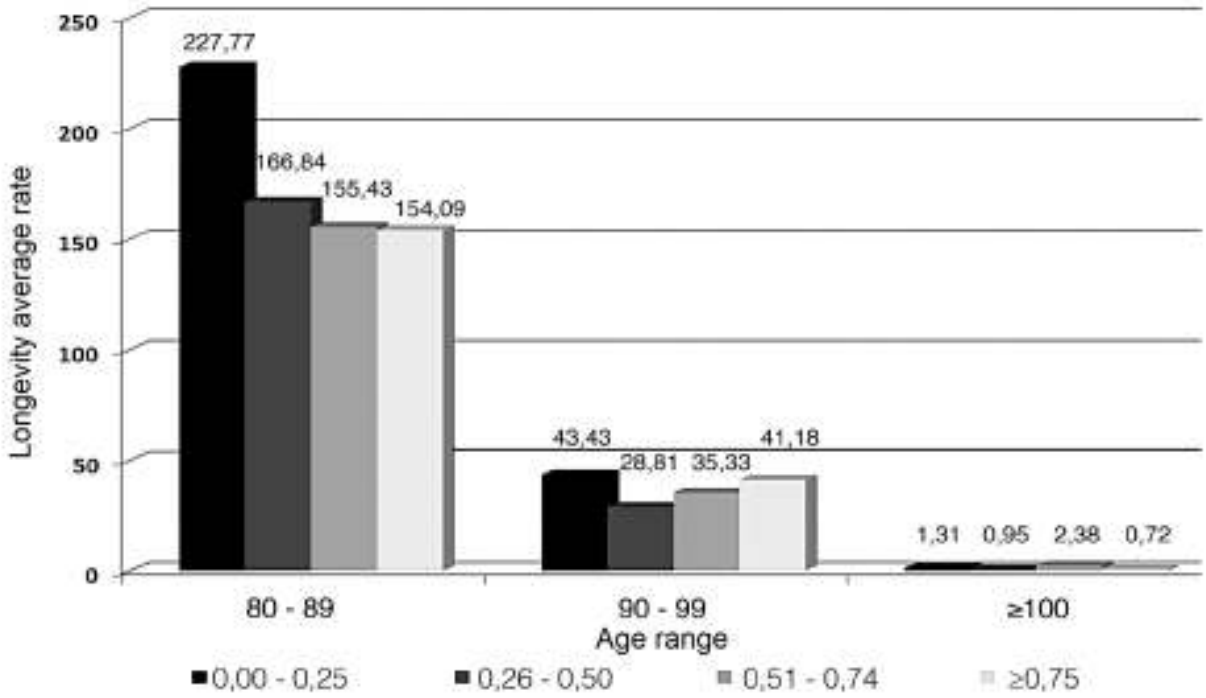

Figure 2. **"Blue Zones"** and control districts: longevity in rates / 10,000 inhabitants, according to average total hardness in the drinking water. Source: Prepared by the authors.

Results of the statistical analysis

Table 4 shows the values of “Probability” (p) of the application of the “Student t-Test”, between the differences in the average longevity rates / 10,000 inhabitants, in the different age segments, and Total hardness intervals. Likewise, the differences in longevity rates between the districts of the Nicoya Peninsula (“Blue Zone”) and the other 30 control districts of the rest of Guanacaste are included.

Table 4. Probability data (Results of the “Student t-test” at 90%, 95% and 99% Confidence)

TABLE 4. PROBABILITY DATA (RESULTS OF THE "STUDENT´S T-TEST" AT 90%, 95% & 99% TRUST RATE)																
INTERVAL	TOTAL HARDNESS			CaCO3 HARDNESS			MgCO3 HARDNESS			BLUE ZONES					
	80-89 Y.O.	90-99 Y.O.	≥100 Y.O.	80-89 Y.O.	90-99 Y.O.	≥100 Y.O.	80-89 Y.O.	90-99 Y.O.	≥100 Y.O.	TOTAL HARDNESS	HARDNESS CaCO3	HARDNESS MgCO3	80-89 Y.O.	90-99 Y.O.	≥100 Y.O.
ONE/TWO	0,993	0,002*	0,057***	0,525	0,018**	0,064***	0,395	0,055***	0,140	0,000021*	0,001*	0,000017*	0,039**	0,004*	0,499
ONE/THREE	0,208	0,003*	0,113	0,566	0,021**	0,172	0,461	0,023**	0,024**						
ONE/FOUR	0,452	0,828	0,870	0,083***	0,408	0,586	0,574	0,424	0,120						
TWO/THREE	0,198	0,481	0,517	0,858	0,479	0,423	0,804	0,823	0,952						
TWO/FOUR	0,449	0,036**	0,078***	0,115	0,744	0,332	0,298	0,236	0,054***						
THREE/FOUR	0,960	0,017**	0,166	0,150	0,477	0,718	0,338	0,140	0,03**						

Source: Author´s elaboration

* Significant difference at 99% confidence. ** Significant difference at 95% confidence. *** Significant difference at 90% confidence.

Note 1: The differences between the “Blue Zones” and the control districts, in the three types of hardness (Total, calcium and magnesium), are statistically significant at 99% confidence with “p” values of 0.000021, 0.001 and 0.000017, respectively.

Analysis of results

Distribution of Guanacaste districts according to the total hardness classification

Table 1 Summarizes the total hardness, calcium hardness and magnesium hardness in HCW (Human Consumption Water), by district average.

The distribution of the 59 districts indicates that 21 of them (35.6%) are in the range of 0-90 mg/L (“Soft Waters”); 23 districts (39%) are classified as “moderately hard” waters (> 90-180); 11 districts (18.6%) consumption “hard” waters (> 180-270 mg/L); and 4 districts (5.8%) “very hard” waters (> 270 mg/L). In summary, of the 59 districts of the 11 Guanacaste cantons, 23 are used for soft water (35.6%) and 36 (64.4%) using “moderately hard” to “very hard” waters.

Total hardness and average longevity rates

The data in Table 2 and the trend observed in Figure 1 indicate that the longevity / 10,000 inhabitant rates are higher from the Total Hardness range of> 180-270 mg/L (waters classified as “hard”). In segment 2, from 90 to 99 years, the difference in longevity rates is from the range> 90-180 mg/L of Total Hardness, that is, "Moderately Hard" water. In the case of segment 3 (=+100 years), a difference of de longevity rates / 10,000 occurs in the Total Hardness range > 90-180 mg/L. These differences are statistically significant at 95% confidence in the segment from 90 to 99 years.

Districts of the Nicoya Peninsula ("Blue Zone") and the control districts

The average results of the 3 types of hardness (Total Hardness, Calcium Hardness and Magnesium Hardness), of the 29 districts of the "Blue Zone", are markedly superior with respect to the averages of the 30 districts used as control. In accordance with these data, the differences in the average rates in the 3 age segments are also greater in the districts of the "Blue Zone" with respect to the control districts. The important thing about these differences is that they were significant at 95% confidence in the age group 80-89 years and at 99% in the range from 90-99 years. On the other hand, in the "Blue Zone", the average total hardness (184.79 mg/L) classifies the water as "hard", while in the 30 control districts it was 95.44 mg/L for a "moderately hard" rating. With respect to calcium hardness, in the districts of the "Blue Zone" it was 116.85 mg/L ("moderately hard") and in the control districts of 64.53 mg/L, also water ("moderately hard "). In the case of magnesium hardness, in the "Blue Zone", the average value was 67.94 mg/L; that is, greater than the "soft" water range (0-30 mg/L).

Finally, no differences were observed in the ratios or proportions of calcium carbonate and magnesium carbonate, and vice versa, in both groups of districts. However, it is observed that the ratio of calcium carbonate and magnesium carbonate is 2.24 and 2.57 times in both intervals. The same is true in reverse, where the two-average data are very similar, 0.66 mg/L ("Blue Zone") and 0.63 mg/L (control districts).

Conclusions and recommendations

Conclusions

A positive association is observed between the Total Hardness contents of the HCW (Human Consumption Water) and the average longevity rates / 10,000 inhabitants, especially in the water classified as "hard" (> 180-270 mg/L) in the segment of 80 to 89 years in the longevity segment of 90 to 99 years and =+100 years, the "big variation" is observed with the "moderately hard" water consumption.

In the segment of =+100 years, an increase in the average rates of longevity in the range greater than 270 mg/L; the one found in water classified as "very hard".

In the comparison of the 29 districts of the "Blue Zones", a difference can be seen, with statistical significance at 99% confidence, in all types of hardness and average longevity rates / 10,000 inhabitants, with respect to the 30 districts used as a control located in the remaining cantons of Guanacaste.

The results obtained, both in the trend of the Total Hardness intervals and the average longevity rates / 10,000 inhabitants, as in the comparison of the "Blue Zone" and the 30 control districts, suggest that hard water is a protective factor in the longevity of the inhabitants of Guanacaste, specifically in the Nicoya Peninsula.

Recommendations

The analysis obtained in the study of trends and the comparison between the data of water hardness and average longevity rates, suggest that water classified as "moderately hard" and "hard" is recommended for the consumption of calcium minerals, magnesium and others, to opt for a long and good life in human beings residing in the respective areas.

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